Space Studies

http://www.space.edu/

FACULTY: Casler (Chair), de León, Dodge (Graduate Program Director), Fevig, Gaffey, Hardersen, Rygalov, and Seelan

Degree Granted: Master of Science (M.S.)

The Department of Space Studies offers graduate studies leading to the Master of Science degree. Non-thesis and thesis options are available. The all-encompassing nature of space exploration requires people who possess broad backgrounds that link policy, business, law, science and engineering. The Department of Space Studies seeks to train this vital segment of the community through the non-thesis option. The goal is to integrate, rather than separate, traditional disciplines related to space. Specialized training is also an essential part of the space community and this is achieved through the thesis option that gives students the opportunity to specialize in an area of faculty research.

Our programs are designed to prepare students for futures in the academic, commercial, and governmental sectors of the rapidly growing field of space exploration and development.

Details pertaining to admission requirements, degree requirements and courses offered can be found in the Degree section.

Master of Science (M.S.)

Mission Statement and Program Goals

The mission of the Department of Space Studies is to provide a comprehensive world-class education in the academic area of space. Key elements of this education are interdisciplinary and multidisciplinary breadth and disciplinary depth, delivered on-campus, and through innovative distance delivery methods. Our objectives focus on producing students that will become the decision and policy makers, managers, negotiators, engineers, technicians, educators and scientists of the space arena.

Facilities for Graduate Research

The department is located on the fifth floor of the 71,500 square-foot Clifford Hall constructed in 1992 as part of the John D. Odegard School of Aerospace Sciences complex on the west end of the UND campus. Our facilities include lab space for the investigation of terrestrial rocks and meteorites, reduction and analysis of terrestrial remote sensing and planetary reflectance spectral data, research into life support technologies and human factors in space, and an astronomical observatory.

The department manages the UND Observatory complex, which is located ten miles west of Grand Forks and two miles southeast of Emerado. The Observatory currently includes three remotely-controllable optical telescopes (two 16-inch and one 10-inch aperture, respectively). UND Observatory telescopes support student thesis and non-thesis astrometric, broadband photometric, and stellar spectrographic research.

A Human Spaceflight Laboratory with several experimental planetary suits is available for student research, as well as a Space Simulators Facility with a vertical and horizontal Space Simulator to replicate different phases of suborbital and orbital flight. The lab also includes elements of a planetary base concept, consisting of an inflatable lunar habitat and pressurized electronic rover which is designed to connect externally to the space suits.

A Space Life Sciences Laboratory is open to students specializing in long-term space physiology, life support scenarios and hardware design.

Aerospace Sciences Degree (Ph.D.)

http://www.aero.und.edu/

FACULTY: (Avit) Anderson, Bjerke, Bridewell, Drechsel, Higgins, Jensen, Kenville (Graduate Program Director), Lindseth, Petros, Robertson, Smith, Ullrich, Vacek, Venhuizen and Watson

FACULTY: (SpSt) Casler (Chair), de León, Dodge (Graduate Program Director), Fevig , Gaffey, Hardersen, Rygalov, and Seelan

Ph.D. in Aerospace Sciences

The Doctor of Philosophy degree in Aerospace Sciences is a joint program between the Department of Aviation and the Department of Space Studies within the John D. Odegard School of Aerospace Sciences. Please refer to the Aerospace Sciences Ph.D. program entry in the graduate section of the catalog.

Mission Statement and Program Goals

The mission of the Aerospace Sciences Ph.D. program is to provide interdisciplinary teaching and research at the highest academic levels. The goal is to provide highly educated scholars and leaders with the skills necessary to mix technology and science with an understanding of the politics and economics of the aerospace fields.

1. Students will develop a thorough knowledge of the aerospace elements specifically related to the Aviation and Space Studies disciplines that will allow them to be successful leaders in the industry by applying solutions gained through theory and applied research.
2. Students will enhance their analytical, technical, research and communication skills through classroom and research activities to further develop an ability to carry out independent, original and applied research.
3. Students will further develop the critical skill set needed to enable them to fill leadership roles within government and research agencies, educational institutions or private aerospace and aviation sector companies.

Master of Science (M.S.)

Admission Requirements

The applicant must meet the School of Graduate Studies' current minimum general admission requirements as published in the graduate catalog. The deadlines for applying for admission for each semester are as follows: April 30 for the Fall semester; October 31 for the Spring semester; and February 28 for the Summer semester. Students who apply after these dates for a given semester are encouraged to do so under non-degree status. The requirements for admission to the Space Studies degree program are as follows:

1. Bachelor's degree from an accredited college or university with an overall grade point average (GPA) of 2.75 or better, or a GPA of at least 3.0 for the junior and senior years of undergraduate work.
2. Three credits of coursework in statistics or algebra or calculus or computer science.
3. Six credits of coursework in the physical sciences, life sciences, or engineering.
4. Six credits of coursework in the social sciences, history, business, or law.
5. Three credits of coursework in English composition or technical writing.
6. Pre-requisite courses from 2 to 5 above must have been completed at the college level, preferably with a grade of B or higher.
7. The Graduate Record Examination (GRE) General Exam if you plan on seeking funding (GRAs, tuition waivers) via the department or a faculty member. Otherwise, it is not required for admission to the MS program.
8. Submission of a written statement of interest highlighting the candidate's interest in space studies and motivation to undertake this program.
9. Satisfy the School of Graduate Studies' English Language Proficiency requirements as published in the graduate catalog.

Financial Assistance

Graduate assistantships (GTA/GRA) are available from a variety of internal and external sources. These are awarded on the basis of academic merit and students' abilities to contribute to departmental research and teaching. Students desiring graduate assistantships must take the GRE. The deadlines for applying for financial aid through the Department of Space Studies for a given semester are as follows: April 30 for the Fall semester; October 31 for Spring semester; and February 28 for Summer semester. Funding is renewable if progress toward the degree, research goals and teaching are satisfactory. Support is typically for two years on a nine-month basis. Summer funding may also be available.

Degree Requirements

All students are required to complete a minimum of 33 credits. The following plan should be used:

1. SPST 501 Survey of Space Studies I and SPST 502 Survey of Space Studies II (6 credits).
2. Students select either the non-thesis or thesis option and declare which social or technical area is their area of specialization. This is the area in which they do their SPST 997 Independent Study Report or SPST 998 Thesis.
3. Two (2) courses from designated social area courses outside the student's area of specialization (6 credits).
4. Two (2) courses from designated technical area courses outside the student's area of specialization (6 credits).
   Note: The choice of courses in the required social and technical areas outside the student's area of specialization must take into account the breadth of disciplines, which is a critical part of Space Studies education. In order to meet the breadth requirements within the degree options, students are required to spread their courses as per guidelines outlined in the Department of Space Studies Graduate Student Handbook.
5. One credit of SPST 590 Space Studies Colloquium (1 credit).
6. At least half of the total credit hours must be from classes at the 500-level and above.

Non-Thesis Option:

1. SPST 997 Independent Study Report (2 credits).
2. Comprehensive Examination.
3. At least 4 elective courses (for distance students, the required Capstone course will count as one elective, so they only need 3).

Distance students must also complete SPST 595 Space Studies Capstone (3 credits).

Thesis Option:

1. SPST 593 Individual Research in Space Studies (1 to 3 credits).
2. SPST 998 Thesis (6 credits).
3. At least 2 elective courses.

Approval of the thesis option will only be granted if a clear alignment of research interests between a faculty member and a student is demonstrated, and a faculty adviser has been identified and is available to supervise the research. Distance students who wish to complete the thesis option must satisfy the residence requirement. Interested students should consult the School of Graduate Studies or department.

Aerospace Sciences Degree (Ph.D.)

Admission Requirements

The applicant must meet The School of Graduate Studies' current minimum general admission requirements as published in the graduate catalog. All elements must be complete by the published application date. The additional requirements for admission to the Aerospace Sciences Ph.D. program are as follows:

1. A Master's or graduate degree from an accredited institution with a GPA of at least 3.25/4.0
2. Submission of a statement of personal goals
3. Professional resume
4. Satisfy the School of Graduate Studies English Language Proficiency requirements as published in the graduate catalog.
5. The Graduate Record Examination (GRE) General Exam
6. Industry experience preferred

Financial Assistance

Financial aid in the form of teaching, research or service assistantships and tuition waivers are available from a variety of internal and external sources and are awarded on a competitive basis. These appointments are renewable if students are making satisfactory progress toward the degree and their work is satisfactory. Applications for funding opportunities should coincide with the program application date.

Degree Requirements

- Ninety credits beyond a baccalaureate degree. With approval of the Aerospace Sciences Ph.D. Program and the UND School of Graduate Studies, up to thirty credits from a master's degree from an accredited institution can be applied toward the requirements of the doctoral degree.
- Successful completion of sixty semester credits beyond the master's degree
- Successful completion of qualifying exam prior to advancement to candidacy
- Twelve to eighteen semester credits of dissertation (AVIT 999 Dissertation or SPST 999 Dissertation) and successful defense of the dissertation
- Required core courses

AVIT 501	General Issues in Aviation/Aerospace	3
SPST 501	Survey of Space Studies I	3
AVIT 521	Ethics in Aerospace	3
AVIT 590 & SPST 590	Aviation Seminar and Space Studies Colloquium	4

- Six to twelve semester credits of Scholarly Tools beyond the Master's degree requirements
- Remaining coursework from Aviation/Space Studies or other UND approved Graduate Courses
- Residency requirement: as determined by student's advisor and/or committee, at a minimum the student will be required to be on campus for one week per year.

There are four required core courses, in addition to the Scholarly Tools component. These courses may have been part of the student's MS program and cannot be counted twice.

AVIT 501	General Issues in Aviation/Aerospace	3
SPST 501	Survey of Space Studies I	3
AVIT 521	Ethics in Aerospace	3
AVIT 590 & SPST 590	Aviation Seminar and Space Studies Colloquium (2 semesters, 2-4 credits total)	2-4

The Scholarly Tools requirement is 6 to 12 semester credits, to be determined by the student's advisor and/or committee, from the courses listed below. These courses are in addition to what may transfer as part of the student's Master's degree program. Therefore, a minimum of six credits will be required as part of the PhD program.

AVIT 503	Statistics (or equivalent)	3
AVIT 504	Research Methods	3
SPST 504	Research Methods in Space Studies	3
AVIT 505	Qualitative Research Methods	3
AVIT 506	Quantitative Research Methods	3
AVIT 507	Advanced Research Methods	3

Course Designations (SPST)

Social area courses		
SPST 450	International Space Programs	3
SPST 540	Space Economics and Commerce	3
SPST 541	Management of Space Enterprises	3
SPST 545	Space and the Environment	3
SPST 551	History of the Space Age	3
SPST 552	History of Astronomy and Cosmology	3
SPST 555	Military Space Programs	3
SPST 560	Space Politics and Policy	3
SPST 561	Public Administration of Space Technology	3
SPST 565	Space Law	3
SPST 574	Remote Sensing in Developing Countries	3
SPST 575	Remote Sensing Law and Policy	3

SPST 581	Field Visit to Space Centers	1-3
Technical area courses		
SPST 405	Space Mission Design	3
SPST 410	Life Support Systems	3
SPST 425	Observational Astronomy	3
SPST 430	Earth System Science	3
SPST 435	Global Change	3
SPST 460	Life in the Universe	3
SPST 500	Introduction to Orbital Mechanics	3
SPST 505	Spacecraft Systems Engineering	3
SPST 506	Advanced Orbital Mechanics	3
SPST 512	Human Performance in Extreme Environments	3
SPST 515	Human Factors in Space	3
SPST 519	Closed Ecological Systems for Life Support	3
SPST 520	Asteroids, Meteorites and Comets	3
SPST 521	The Planet Mars	3
SPST 522	Remote Sensing Principles	3
SPST 523	Remote Sensing Applications	3
SPST 524	Current Topics in Astrobiology	3
SPST 525	Technical Issues in Space	1-3
SPST 526	Astronomical and Spacecraft Instrumentation	3
SPST 527	Extraterrestrial Resources	3
SPST 528	Space Environment and the Sun	3
SPST 570	Advanced Topics in Space Studies (may count towards either social or technical area depending on the contents.)	1-3

Cognate/Minor

The Department of Space Studies invites students from other programs who wish to expand their program of study to include a space-related focus. Our program includes a multidisciplinary set of course offerings that integrate well with other graduate programs. Students interested in space engineering, space business, space law, space policy, space science, space life sciences, space history, or military space can be accommodated. To complete a cognate or minor at the master's level, students must take three courses for nine semester hours of credit. Our department will work with those doctoral students whose department requires additional credits for a minor degree.

AVIT Courses

AVIT 501. General Issues in Aviation/Aerospace. 3 Credits.
This course is designed to introduce students to graduate school, library resources, and faculty research interests. This course explores the historical, current and future issues related to the aerospace industry.

AVIT 502. Aviation Economics. 3 Credits.
An in-depth examination of the economic aspects of the air transportation industry, with microeconomic analysis applied to decision making in the airline, general and corporate aviation, and airports. Topics include: basic economics of air transport supply and demand; demand forecasting; cost drivers; yield, revenue and capacity management; regulatory issues; political influences; and unique economic characters of international commercial aviation.

AVIT 503. Statistics. 3 Credits.
This course is an in-depth study of inferential statistics with emphasis on the analysis of variance models and subsequent comparison procedures. In addition, the course will include coverage of correlation and multiple regression techniques as data analytic tools. Also, coverage of survey construction and analysis of survey data will be presented. Course content will be presented within the context of aviation and psychology examples. (Psychology 541: Advanced Univariate Statistics can be substituted for AVIT 503). Prerequisite: An introductory statistics course or calculus course.

AVIT 504. Research Methods. 3 Credits.
Methods and procedures of development, design and analysis related to aviation industry research. Topics include problem identification, review of literature, research design, and data analysis. This course is designed to give an overview of quantitative, qualitative and mixed-method approaches research design. The course includes the experience of critically evaluating research projects and developing a research project based on the principles discussed in class. Prerequisites: AVIT 501, and AVIT 503 or PSYC 541. F.

AVIT 505. Qualitative Research Methods. 3 Credits.
Examination and analysis of qualitative research design with particular emphasis on approaches relevant to problems in Aerospace Studies or related fields. Students will design a qualitative research project.

AVIT 506. Quantitative Research Methods. 3 Credits.
The purpose of this course is to provide students the opportunity to acquire knowledge and skills necessary to apply quantitative research methods in research. Students will design a quantitative research project. Prerequisite: A graduate level Statistics course.

AVIT 507. Advanced Research Methods. 3 Credits.
This course will be a thorough discussion of the different methodologies utilized in theoretical and applied research. Experimental and quasi-experimental design, and topical areas of survey methodology data mining, simulations, and techniques for dissertation designs. Prerequisites: AVIT 503, AVIT 505, and AVIT 506.

AVIT 510. Aviation Public Policy and Regulations. 3 Credits.
A discussion of the initiation, formulation and implementation of aviation public policies and their effects upon the various segments of the aviation industry. Various regulatory areas such as scheduled air carriers, general aviation, airport operations, air traffic control and international agreements will be analyzed.

AVIT 511. Aviation Information Technology. 3 Credits.
This course is an introduction to information systems essential to an aviation business professional. It will provide an overview of current and emerging technologies in various database, data communication and e-commerce systems.

AVIT 512. Aviation Environmental Issues. 3 Credits.
This course examines current environmental issues within the aviation industry in the context of historical environmentalism, current laws and regulations, and emerging research findings. A broad survey of earth systems precedes a focused examination of contemporary aviation environmental issues.

AVIT 513. Aviation Safety Management Systems. 3 Credits.
An in-depth study of aviation safety management concepts and principles as they relate to effective safety programs within the airlines, corporate aviation, general aviation and airports.

AVIT 514. Aviation Management Theory. 3 Credits.
An in-depth review of organizations in the aviation industry, their structures, environments and leadership as it relates to human behavior. Topics include organizational design, climate and the interactions with individuals, groups, and different organizational structures within the airline, general aviation, corporate aviation and airport organizations.

AVIT 515. Human Factors: Human Perceptions in Information Systems Design. 3 Credits.
Human perception and information processing will be discussed in relation to information system design requirements to optimize human performance. Topics include information systems design with regard to compatibility, perception, attention, situation awareness and decision processes. Applications to current workstation design will allow students to have a greater understanding of human centered design goals.

AVIT 516. Training System Design. 3 Credits.
The process of memory, learning, and judgment will be related to instructional design strategies in the aviation industry, where heavy use of simulation is used in the training and evaluation of aviation professionals. Topics include instructional design and assessment concepts, simulation design and decision making skills. Class presentations include operational problem-solving group work as well as research paper reviews.

AVIT 517. Airline Labor Relations and Law. 3 Credits.
This course will examine the impact and application of the Railway Labor Act as it pertains to airline operations. Topics of study will include labor history; organization; alternative dispute resolution, collective bargaining, including interest-based practices; and emerging labor trends.

AVIT 518. Human Error. 3 Credits.
The objective of this course is to develop a deeper understanding of the human error and its impact upon human performance in variety of fields. Prerequisite: Graduate Admission. S.

AVIT 520. Strategic Airport Planning. 3 Credits.
This course will explore the elements of airport planning within the public administration domain. Emphasis will be placed on individual airport's strategic plans, how airports operate efficiently and effectively with changing regulations and economic fluctuations in the global marketplace.

AVIT 521. Ethics in Aerospace. 3 Credits.
The course will introduce ethical concepts and frameworks used in professional decision-making. Students will engage with faculty and outside speakers to weigh decisions in the applicable ethical frameworks. Students participation will include graded elements of formal case presentations, class discussion sessions, essay examinations and review of scholarly and trade journal articles. The course will have a strong emphasis on research project design to assess dynamics of ethical decision-making in different populations, as well as exploring educational opportunities in the aerospace industry.

AVIT 522. UAS Management. 3 Credits.
This course provides a series of lectures or presentations by visiting lecturers or faculty on various themes related to Unmanned Aircraft Systems (UAS). Prerequisite: Graduate Student Status. F, odd years.

AVIT 523. Aviation Safety Data Analysis. 3 Credits.
The objective of this course is to obtain an understanding of various safety programs conducted throughout the aviation industry and examine the underlying analytical techniques associated with each program. Prerequisite: Graduate student status. SS.

AVIT 524. Air Traffic Management. 3 Credits.
This course will explore the elements of Air Traffic and Next Gen. There will a discussion on how air traffic control works and the evolution of the Air Traffic Management of the National Airspace System in the US and abroad. Emphasis will be on the current day issues and how Air Traffic Management is changing not only in the US but in Canada, Europe and worldwide. Prerequisite: Admission (or conditional admission) to the Aviation Master of Science, The Aerospace PhD program, or consent of the instructor. S, odd years.

AVIT 525. Legal Issues in Aviation. 3 Credits.
The course will introduce legal concepts and frameworks of the United States' legal system. Issues particular to the aviation industry will be discussed. Students will engage in formal case presentations and discussions to gain an understanding of the legal issues faced in the aerospace industry. Prerequisite: Admission (or conditional admission) to the Aviation Master of Science program, the Aerospace PhD program, or consent of the instructor. SS, even years.

AVIT 587. Supervised Field Work. 1-3 Credits.
Used primarily for individualized field placement so that the student may acquire practical experiences in the aviation industry. Prerequisite: Consent of graduate director. Repeatable to 6 credits. S/U grading.

AVIT 590. Aviation Seminar. 1-3 Credits.
A series of lectures presented by visiting lecturers and the faculty. Repeatable to 9 credits.

AVIT 591. Readings in Aviation. 1-3 Credits.
Readings in selected Aerospace Studies topics, with written and/or oral reports. Prerequisite: Consent of instructor. Repeatable to 6 credits.

AVIT 593. Individual Research in Aviation. 1-3 Credits.
Individual student projects designed to develop advanced knowledge in a specific area of expertise. A written report is required. May be repeated for up to 6 credits for Master's and up to 12 credits for Ph.D. Repeatable to 6 credits.

AVIT 595. Aviation Capstone. 3 Credits.
The Capstone course integrates, extends and applies knowledge learned in earlier Aviation courses and research projects. The course also undertakes an in-depth study of management theories relevant to the aviation industry and how leaders apply these theories in practice. Students will have the opportunity to demonstrate their knowledge and leadership abilities by working in teams to design and develop a solution to a current aviation problem, which will be assigned by the instructor. This effort will culminate in an on-campus presentation to the faculty and invited industry experts. Prerequisite: AVIT 504 or permission of instructor.

AVIT 996. Continuing Enrollment. 1-12 Credits.
Repeatable. S/U grading.

AVIT 997. Independent Study. 2 Credits.
Independent study and preparation of a written report for students taking the non-thesis option in the Master's program.

AVIT 998. Thesis. 4 Credits.
Preparation and defense of a thesis based on original research. Prerequisite: Admission committee approval and consent of instructor. Repeatable to 4 credits.

AVIT 999. Dissertation. 1-12 Credits.
An original research project approved by and completed under the supervision of a dissertation committee. Prerequisites: Graduate standing, approval, completion, and defense of dissertation proposal. Repeatable to 18 credits.

SPST Courses

SPST 500. Introduction to Orbital Mechanics. 3 Credits.
This course introduces students without much background in either mathematics or physics to the problems faced everyday by orbital analysts as they track the 7000 satellites which orbit the earth. The course gives the students an ability to converse, as managers and co-workers, with those individuals who are calculating these difficult orbits. This appreciation is important in both the civilian and military sides of the space program. On demand.

SPST 501. Survey of Space Studies I. 3 Credits.
SPST 501 is the first course in a two-course sequence (along with SPST 502) in Space Studies that introduces new students to essential knowledge that will be necessary to successfully complete their M.S. degree in space studies. SPST 501 consists of the following six modules: 1) space history, 2) space policy, 3) space law, 4) planetary and space sciences, 5) space life sciences and human factors, and 6) Earth remote sensing. All modules contain foundational information that will give students the basic knowledge and skills necessary to achieve a broad understanding of the multi- and inter-disciplinary nature of space studies; knowledge that can be applied in later courses, such as Capstone; and knowledge that facilitates thesis and other specialized types of instruction and research. Course content in SPST 501 will also be used to assess student learning at the end of their M.S. program via the Comprehensive Examination. Students are expected to master and understand course content, be able to apply course content as appropriate, and demonstrate their understanding of course content prior to graduation. F.

SPST 502. Survey of Space Studies II. 3 Credits.
SPST 502 is the second course in a two-course sequence (along with SPST 501) in Space Studies that introduces new students to essential knowledge that will be necessary to successfully complete their M.S. degree in space studies. SPST 502 consists of the following five modules: 1) space mission design (two modules), 2) orbital mechanics, 3) launch vehicles and propulsion, and 4) robotic spacecraft instrumentation. All modules contain foundational information that will give students the basic knowledge and skills necessary to achieve a broad understanding of the multi- and inter-disciplinary nature of space studies; knowledge that can be applied in later courses, such as Capstone; and knowledge that facilitates thesis and other specialized types of instruction and research. Course content in SPST 502 will also be used to assess student learning at the end of their M.S. program via the Comprehensive Examination. Students are expected to master and understand course content, be able to apply course content as appropriate, and demonstrate their understanding of course content prior to graduation. S.

SPST 504. Research Methods in Space Studies. 3 Credits.
This course will provide an introduction to research in Space Studies emphasizing the preparation of a Ph.D. proposal and the dissertation itself. Course content will be tailored to address the specific research methods applicable to the student(s) research interests. Typically given by the student's advisor, but students preparing in the same area (e.g., Planetary Science, Astronomy) may be in a combined section. On demand.

SPST 505. Spacecraft Systems Engineering. 3 Credits.
This course will guide the students through the spacecraft design and proposal process for an actual mission. In this course the students will work in teams on individual spacecraft subsystems, participate in an engineering design review, and create a document which can be submitted for funding for a small satellite project. Lectures will provide an overview of the separate spacecraft subsystems involved in a typical mission, the systems engineering approach to spacecraft development, and the grant writing process. Distance students will interact with on-campus students via conferencing software. Prerequisite: SPST 405 or consent of instructor.

SPST 506. Advanced Orbital Mechanics. 3 Credits.
This course provides a working knowledge of the field of orbital mechanics including the use of appropriate mathematical and computational techniques, the analysis of professional papers in orbital mechanics, and applying the appropriate techniques to solve orbital mechanics problems. Topics covered include orbital elements, perturbations, coordinate systems, orbit determination, and multi-body gravitational problems. Prerequisites: SPST 500, and MATH 266 or equivalent.

SPST 508. Quality Engineering for the Space Industry. 3 Credits.
This course addresses the principles and techniques for establishing quality goals, identification of customer needs and requirements, measurement of quality, and product/process engineering to improve system performance with a focus on the space industry. The main objectives are to provide the student with an understanding of the principles and practice of quality and reliability engineering in general and to provide an in-depth understanding of the quality assurance concepts, strategies, and tools practiced in the space industry. Familiarity with the techniques learned in this course will enable the student to address problems in the design, implementation, measurement, and correction of production and service systems found in the space industry. On demand.

SPST 512. Human Performance in Extreme Environments. 3 Credits.
This course introduces the area of human performance in extreme environments, highlights differences and similarities between extreme environments, and demonstrates the lessons learned from one extreme environment can be effectively applied to others--though settings like space, mountains, or the ocean's depths, etc. pose unique characteristics, the human physiological and psychological reactions and adaptations to these extreme settings stay similar.

SPST 515. Human Factors in Space. 3 Credits.
A review of the major stresses experienced by humans on entering the new and alien environment of space. Examples will be taken from the psychological and physiological impacts experienced by U.S. and Soviet crews with emphasis on longer flights. How to avoid and/or overcome these stresses will be examined as an essential and growing need in the future development and settlement of the space frontier.

SPST 517. Human Spaceflight Systems. 3 Credits.
This course is designed to introduce students to human space systems. The course uses both an engineering and a historical approach to human spaceflight systems covering all manned spacecraft up to today, plus individual subsystems necessary for human occupation. By the end of the course, students will: 1. Understand the engineering and science concepts related to human spaceflight, 2. Understand the major technologies required for human spaceflight, 3. Apply the systems engineering process to a human spaceflight mission: a. Describe the interactions among the elements of a space mission, b. Describe the interactions among all spacecraft subsystems, c. Document design decisions and analysis in a clear and concise manner. F, even years.

SPST 519. Closed Ecological Systems for Life Support. 3 Credits.
Closed ecological systems have been suggested during the early decades of space exploration for extended life support in space operations. In reality, this principle of long-term life support mimics global biogeochemical cycles supporting life on Earth. The course covers the multiple interactions of human/bioregenerative life support based on physical/chemical regeneration (hybrid) life support environments. Extensive research in this area during more than five decades showed that material turnover in small closed environments becomes unstable compared to a planetary environment. Specific attention is paid to the limits of stability for closed material cycles functioning during long-term remote confined missions; and the importance of the human factor as a target link, main sensor, and main integrator and control element for the system providing significant self-sustainability under proper motivation. Advanced scenarios for space life support based on ecological and in situ resource utilization approaches are discussed. On demand.

SPST 520. Asteroids, Meteorites and Comets. 3 Credits.
The small bodies of the solar system provide clues to the origin and early history of the solar system. The planets and larger moons have all been chemically transformed erasing their records of their formation. By contrast, many asteroids, meteorites and comets are essentially unmodified from the time of their origin 4.5 billion years ago and thus preserve a record of the formation epoch. Each of these classes of objects is investigated separately, and relationships between them are examined. Implications for impact hazards and for extraterrestrial resources are also explored. The results of recent and current spacecraft missions to asteroids (e.g., Galileo, NEAR, DAWN, Hayabusa, Rosetta, OSIRIS-Rex, etc.) and to comets (e.g. Giotto, Vega 1, Stardust, Deep Impact, Rosetta, etc.) are reviewed. On demand.

SPST 521. The Planet Mars. 3 Credits.
This course provides an in-depth review of the present state of our knowledge of the planet Mars. Topics that are covered include: the origin and evolution of the planet, the surface geology and geological processes, the geophysical properties of the Martian interior, the origin and evolution of the Martian atmosphere, the present and past climates of Mars, the Martian moons, and the possibility of past or present life on Mars. The American, Soviet/Russian and other nations' Mars exploration programs are reviewed and the course incorporates the most recent results from spacecraft missions such as Mars Odyssey, the Mars Exploration Rovers (Opportunity Spirit), Mars Express (European Space Agency), Mars Reconnaissance Orbiter, Mars Science Laboratory (Curiosity Rover), MAVEN, and Mangalyaan (India's Mars Orbiter Mission). Potential future manned and unmanned missions are also discussed. On demand.

SPST 522. Remote Sensing Principles. 3 Credits.
This course covers the basic concepts and foundations of remote sensing, a review of major Earth observing satellite and aircraft platforms, and an investigation of flow of data from satellite to Earth, what it represents, and how to interpret it, using both visual and digital image processing techniques. A field visit to the EROS Data Center in Sioux Falls may also be arranged.

SPST 523. Remote Sensing Applications. 3 Credits.
This course covers the use of advanced image processing algorithms and information extraction techniques for various Earth resource applications such as land cover/land use, environmental change detection, geology, oceanography, agriculture, forestry, rangeland, water resources, urban planning, natural disaster management, etc. Prerequisite: SPST 522.

SPST 524. Current Topics in Astrobiology. 3 Credits.
This is a multi-disciplinary, literature-intensive examination of astrobiology, which is the study of life in the universe. Students will read scientific research and review papers from a variety of disciplines including astronomy, planetary science, chemistry, biology, and geology. Course goals include: developing proficiency at reading/analyzing diverse scientific papers, developing the ability to incorporate knowledge from multiple disciplines in the study of astrobiological research, and developing the ability to effectively write summary papers to show basic understanding of course material. Prerequisite: SPST 460 or consent of instructor. On demand.

SPST 525. Technical Issues in Space. 1-3 Credits.
An examination of the technological base for the exploration and development of space. An understanding of this technology and of its impact is essential to an understanding of the issues and problems associated with our continuing efforts to explore and settle this new frontier. May be repeated if the topic is different. Repeatable.

SPST 526. Astronomical and Spacecraft Instrumentation. 3 Credits.
This course will concentrate on instrument design, operation, and the resulting data products generated by ground- and space-based astronomical observatories, as well as common instrumentation used in NASA scientific solar system spacecraft. Key goals for this course include gaining a solid understanding of instrumental principles of operation, the types of raw data that are generated, and the types of data reduction processes that lead to interpretable data. The course will include an investigation of different types of spectrographs and spectroscopy data products, solar instrumentation (ground- and space-based), terrestrial and Jovian spacecraft orbiter/flyby instrumentation, terrestrial planet rover and lander instrumentation, and extra-solar system astrophysical instrumentation. Students will have the opportunity to examine, reduce, and interpret select data sets. Prerequisites: SPST 425 and MATH 165 or consent of instructor. On demand.

SPST 527. Extraterrestrial Resources. 3 Credits.
This course focuses on the inventory, accessibility, acquisition, processing and utilization of extraterrestrial resources (space resources) from celestial bodies such as the Moon, Mars, asteroids and comets. Consideration will be given to extraterrestrial resources for in situ utilization (such as a Lunar or Martian base), for space operations (such as supporting large scale near-Earth activities or a human Mars mission), and for terrestrial markets. The course will focus on the interplay between the scientific, technical, and economic aspects of acquiring and utilizing such resources. The course will also explore some of the legal and political ramifications and limitations of claiming and recovering space resources. On demand.

SPST 528. Space Environment and the Sun. 3 Credits.
This course will provide an in-depth study of the science and observations of the Sun, space weather, and effects of the Sun on astronauts, Earth, and the space environment. Topics that will be covered include the solar photosphere and active surface phenomena such as sunspots, flares, and coronal mass ejections; the nature of the quiet Sun; the solar interior and helioseismology; space weather and impact of solar particles on the space environment and Earth; the hazards posed to astronauts by solar eruptions; common techniques of solar observations; and a review of the primary types of solar instrumentation and the observatories that currently study the Sun. Students will be able to observe the Sun using the UND Observatory's small solar telescopes; all students will have the opportunity to analyze solar datasets to aid their understanding of the Sun. Prerequisite: MATH 165 or consent of instructor. On demand.

SPST 540. Space Economics and Commerce. 3 Credits.
A study of the economic aspects of space activities, with analysis of the possibilities and the barriers. Key areas include launch services, satellite communications, remote sensing, microgravity materials processing, and interaction with the government. Global competition against subsidies or government-sponsored entities is examined. On demand.

SPST 541. Management of Space Enterprises. 3 Credits.
This course investigates the management of space organizations. These include organizations that are public and private, RD and operations, profit and non-profit. You will learn the basics of management theory, the history of systems management, and the technical issues that must be considered in the management of space RD and operations. On demand.

SPST 542. Risk Management of Space Organizations. 3 Credits.
This course includes a systematic approach to the principles and practices of risk management in the space industry from project initiation through planning, implementation, control and closeout. It discusses various techniques and models for qualitative and quantitative risk assessment and risk mitigation in such areas as cost, schedule, and performance. Decision making under conditions of uncertainty and risk is also discussed. On demand.

SPST 545. Space and the Environment. 3 Credits.
This course is an advanced graduate-level review of international relations theories as applied to the international implications of global commons. The course introduces the concept of global commons, examines the theories and practices concerning management of global commons, and analyzes the global commons dealing with the problems of collective action as applied to global environmental change and the uses of outer space. On demand.

SPST 551. History of the Space Age. 3 Credits.
This course introduces students to the history of human endeavors in space. These include the development of rocketry, the influence of amateur societies and science fiction, the military development of ballistic missiles, and human and robotic spaceflight.

SPST 552. History of Astronomy and Cosmology. 3 Credits.
This course investigates the history of human endeavors to understand the stars, planets, and cosmos as a whole from a scientific perspective. It covers the early observations and theories of the Babylonians and Greeks through the European Scientific Revolution, and finally to the development of astrophysics and modern cosmology using space vehicles. On demand.

SPST 555. Military Space Programs. 3 Credits.
An introduction to military uses of space by the United States, Russia, and other nations. The course introduces ballistic missiles, anti-ballistic missile and anti-satellite systems, space-based reconnaissance and intelligence-gathering, communications, navigation, acquisition, and military space treaties. On demand.

SPST 560. Space Politics and Policy. 3 Credits.
This course serves as a graduate-level introduction to the field of Public Policy as applied to Space Policy. The course surveys the evolution of Space Policy at several levels of analysis including context, political actors and institutions, political processes, and policy outcomes, and assesses the symbiotic relationship between policy, technology, and science. On demand.

SPST 561. Public Administration of Space Technology. 3 Credits.
This course is an advanced graduate-level review of Public Administration theories as applied to the implementation of space technology programs. In this course, the political, organizational, and technical variables that affect the management processes of space organizations are examined. Prerequisite: SPST 560 or SPST 541. On demand.

SPST 565. Space Law. 3 Credits.
This course serves as a graduate-level introduction to the field of Law as applied to Space Law. The course examines the origins and evolution of the laws of outer space from the beginnings of the space age to the present. International laws governing access and use of space, and national laws regulating governmental and commercial activities in space are reviewed and analyzed. On demand.

SPST 570. Advanced Topics in Space Studies. 1-3 Credits.
Lecture, discussion and readings on advanced topics of current interest. May be repeated if the topic is different. Repeatable.

SPST 574. Remote Sensing in Developing Countries. 3 Credits.
This course will introduce students to remote sensing programs in developing countries and typical remote sensing application areas pertinent to developing countries, such as: potable water, forest fires, vector diseases, environmental degradation, food security, fisheries, floods, droughts, crop pests, etc., with case studies. Prerequisite: SPST 522 or GEOG 475 or consent of instructor. On demand.

SPST 575. Remote Sensing Law and Policy. 3 Credits.
This course focuses on the evolving laws, policies, and institutions that have long-term ramifications for earth observations. Some topics addressed are the United Nations Principles on Remote Sensing; the United Kingdom's 1984 National remote sensing policy; the Montreal Protocol; and, the United States Land Remote Sensing Policy Act of 1992. Ground segment institutions considered are the Landsat Ground Stations Operations Working Group and the Global Land 1-KM AVHRR Project. Remote sensing litigation that has begun to address various applications of remote sensing will also be considered, and the impact of remote sensing activities on privacy and constitutional law will be examined. Cases include Dow vs US and EOSAT vs NASA and NOAA. On demand.

SPST 581. Field Visit to Space Centers. 1-3 Credits.
This course will provide a first-hand knowledge of selected space centers in the U.S. and/or abroad through an organized field visit. The field visit will be led by a space studies faculty and will include prior preparation through readings, class seminars, lectures and written assignments. May be repeated up to a maximum of 3 credits. Repeatable to 3 credits. S/U grading. On demand.

SPST 590. Space Studies Colloquium. 1 Credit.
A series of lectures presented by visiting lecturers and faculty. May be repeated for up to 2 credits. S/U grading.

SPST 591. Readings in Space Studies. 1-3 Credits.
Readings in selected Space Studies topics, with written and/or oral reports. Repeatable to a maximum of 6 credits. Prerequisite: Consent of instructor. Repeatable to 6 credits.

SPST 593. Individual Research in Space Studies. 1-3 Credits.
Individual student projects designed to develop advanced knowledge in a specific area of expertise. A written report is required. May be repeated for up to 6 credits for Master's and up to 12 credits for Ph.D. Repeatable to 6 credits.

SPST 595. Space Studies Capstone. 3 Credits.
The capstone course integrates, extends and applies knowledge gained in earlier Space Studies courses and reading. The major component of this course is a collaborative team project inter-relating policy, technology and science. This course is required for distance students who select the non-thesis option and can be taken after completing at least 21 credits in the program, or with the permission of the instructor. The course begins in the fall semester and concludes with a required week-long capstone experience on the UND campus in the spring. Prerequisites: SPST 501 and SPST 502. F.

SPST 996. Continuing Enrollment. 1-12 Credits.
Prerequisite: Department consent. Repeatable. S/U grading.

SPST 997. Independent Study Report. 2 Credits.
Independent study and preparation of a written report for students taking the non-thesis option in the Master's program.

SPST 998. Thesis. 1-6 Credits.
An original research project approved by and completed under the supervision of a thesis committee. Repeatable to 6 credits. Prerequisites: Graduate standing in Space Studies and completion and approval of a thesis proposal (see department for approval). Repeatable to 6 credits.

SPST 999. Dissertation. 1-12 Credits.
An original research project approved by and completed under the supervision of a dissertation committee. Prerequisites: Graduate standing, approval, completion, and defense of dissertation proposal. Repeatable to 18 credits. F,S,SS.

Undergraduate Courses for Graduate Credit

SPST 405. Space Mission Design. 3 Credits.
A team design project to develop the requirements for a space mission. The specific mission will vary from time to time. Design teams will work on selected portions of the mission. Accompanying lectures will provide background material. Prerequisite: SPST 200. S.

SPST 410. Life Support Systems. 3 Credits.
A review of the physiological effects of living in space including a discussion of current and near-term life support systems equipment for the provision of oxygen, water, food, and radiation protection. In addition, a review will be made of the issues associated with the development of fully closed ecological life-support systems that will be essential to the long-term development of space. Prerequisite: SPST 200. On demand.

SPST 425. Observational Astronomy. 3 Credits.
This course provides an introduction to observational astronomy and includes three segments: basic observing techniques and astronomical equipment (telescopes, CCDs); visual observing and the characteristics of the night sky; astrometric and photometric observing, data reduction, and interpretations; and image processing and color imaging techniques. Students will learn to operate a remotely controllable Internet telescope and CCD camera. A broadband Internet connection is recommended. Night observing is required. Course fee. Prerequisite: PHYS 110. On demand.

SPST 430. Earth System Science. 3 Credits.
This course begins with a review of the physical sciences of geology, meteorology and oceanography to examine the coupled interactions between the land, atmosphere and oceans. Particular emphasis is placed on remote sensing techniques for global monitoring of biogeochemical processes. The role of human activities on Earth processes and the consequences of global environmental changes are discussed. The growing use of space-based data sets and the implications of Earth Observing System technologies, including research goals and hardware requirements, are examined. Prerequisite: SPST 200. On demand.

SPST 435. Global Change. 3 Credits.
The current human population represents something unprecedented in the history of the world. Never before has one species had such a great impact on the environment in such a short time and continued to increase at such a rapid rate. Human activities are therefore significantly influencing the Earth's environment in many ways in addition to greenhouse gas emissions and climate change. Anthropogenic changes to Earth's land surfaces, oceans, coasts, and atmosphere and to biological diversity, the water cycle and biogeochemical cycles are clearly identifiable beyond natural variability. This course investigates the many facets of global change issues, and attempts to provide an up-to-date introduction to the study of the Earth's environment. F, even years.

SPST 450. International Space Programs. 3 Credits.
This course will introduce students to the major governmental space programs around the world. The history, activities and future directions of the Russian/Soviet, European/ESA, Chinese, Japanese, Indian and other space programs will be explored. International collaborations between the various programs will also be studied. Prerequisite: SPST 200. On demand.

SPST 460. Life in the Universe. 3 Credits.
This course examines the nature and evolution of life on Earth from its origin to the present time in the context of cosmological evolution, chemical evolution, planetary evolution, biological evolution, and cultural evolution. The possibility of life elsewhere in the universe is considered based on the conditions under which life could arise and flourish. Human changes to the Earth are placed within this context. The future of life on Earth is discussed and the social and cultural implications arising from the discovery of extraterrestrial life are explored. On demand.